(12) UK Patent Application (19) GB (11) 2 271 031 (13) A

(43) Date of A Publication 30.03.1994

(21) Application No 9219938.9

(22) Date of Filing 21.09.1992

(71) Applicant(s)
Rosemount Limited

(Incorporated in the United Kingdom)

Heath Place, Bognor Regis, West Sussex PO22 9SH, United Kingdom

(72) Inventor(s)
James Stewart Johnston
Mark Seton Beales

(74) Agent and/or Address for Service
Boult Wade Tennant
27 Furnival Street, LONDON, EC4A 1PQ, United Kingdom

(51) INT CL^5
H03M 1/22

(52) UK CL (Edition M)
H3H HCD H1C H5D

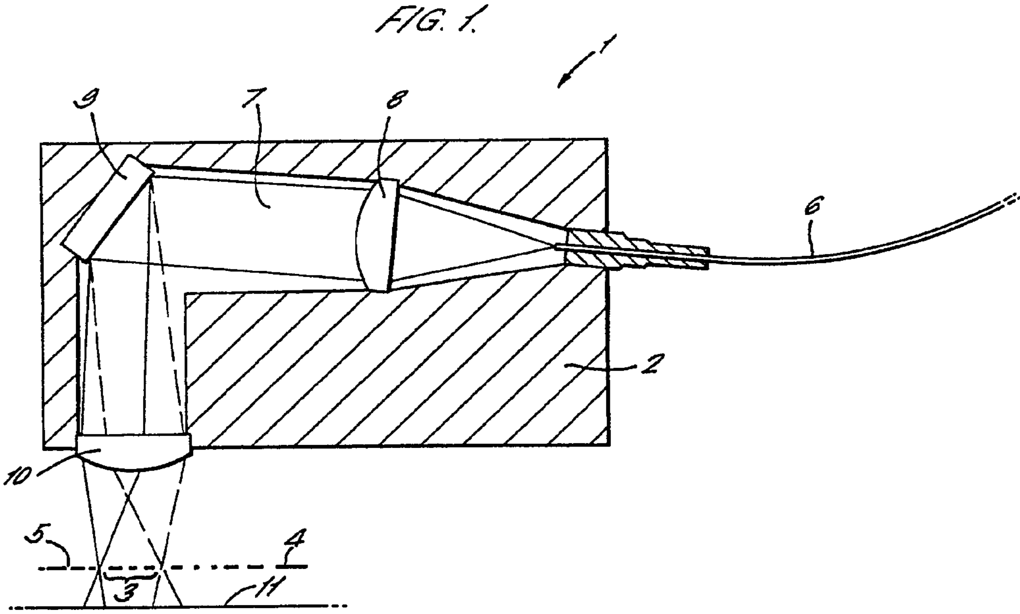
(56) Documents Cited
GB 1585561 A

(58) Field of Search
UK CL (Edition K) H3H HCD
INT CL^5 H03M
Online databases:WPI

(54) **Displacement encoder**

(57) A sensor head (2) is operable to direct light onto a selected portion (3) of an optically detectable coded track (4). A retroreflector (11) returns the encoded light so as to be received by the sensor head (2), the retroreflector (11) being operable to reflect obliquely incident light through 180°. The track (4) may be coded such that light is encoded by transmission through the track and the retroreflector (11) may be a sheet of reflective transparent beads having a reflective coating to provide internal reflection. The apparatus allows alignment tolerances to be relaxed and reduces light losses.

FIG. 1.



GB 2 271 031 A

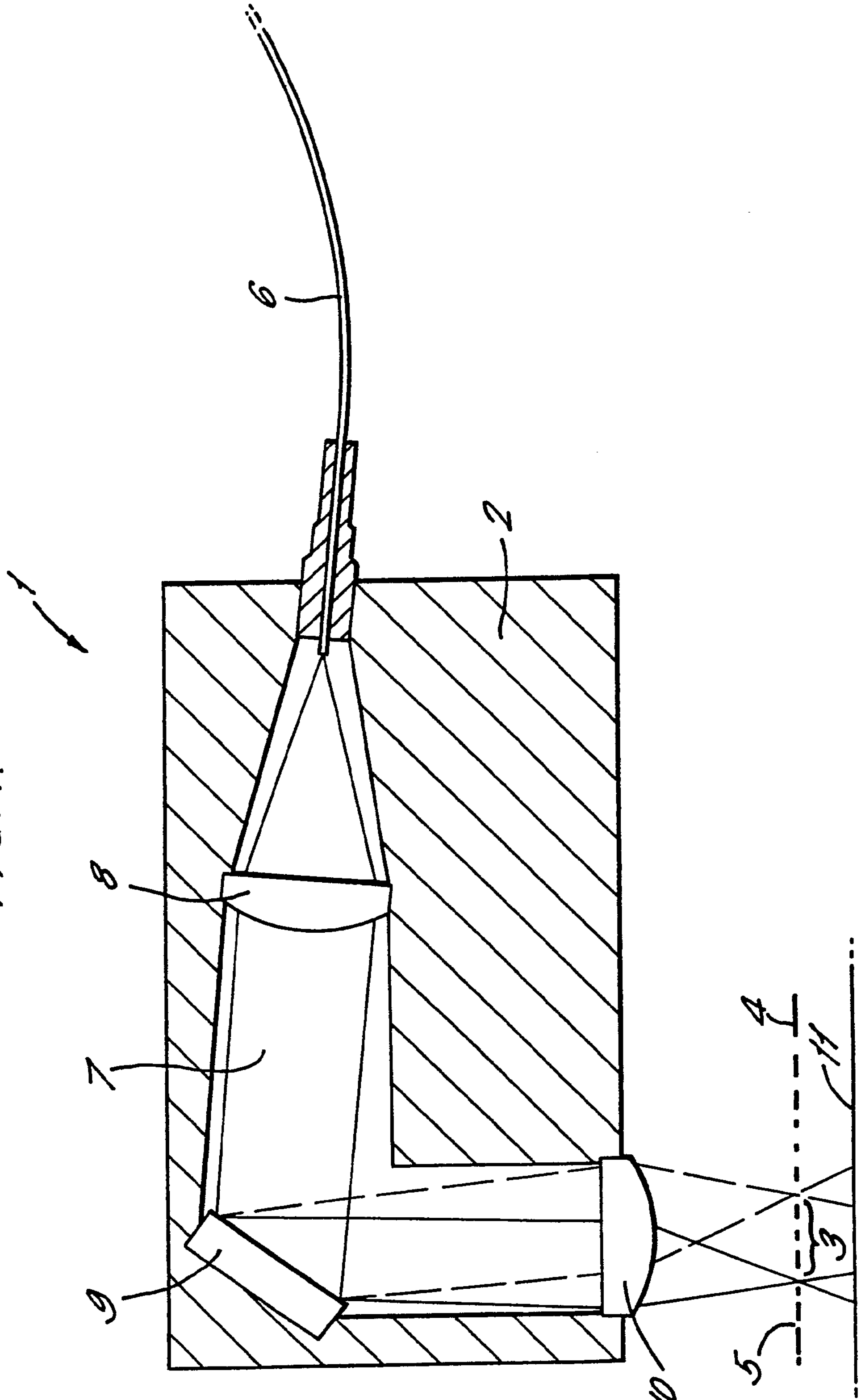


FIG. 1.

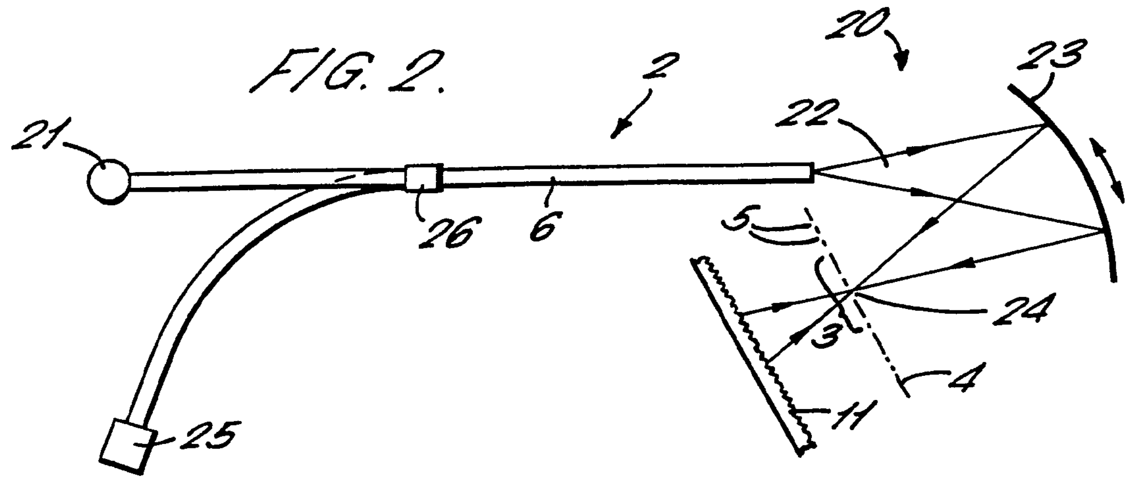


FIG. 2.

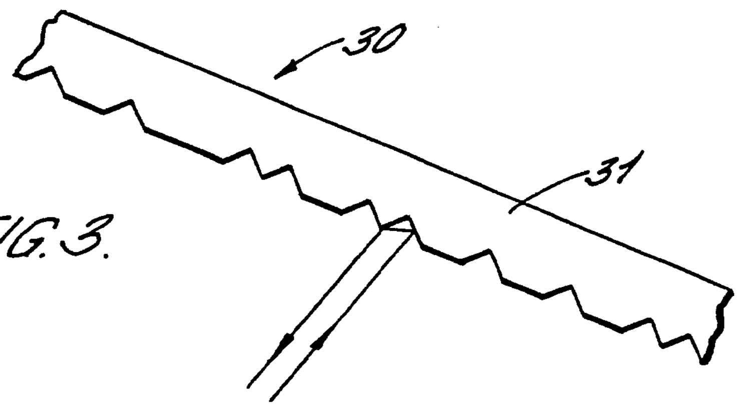


FIG. 3.

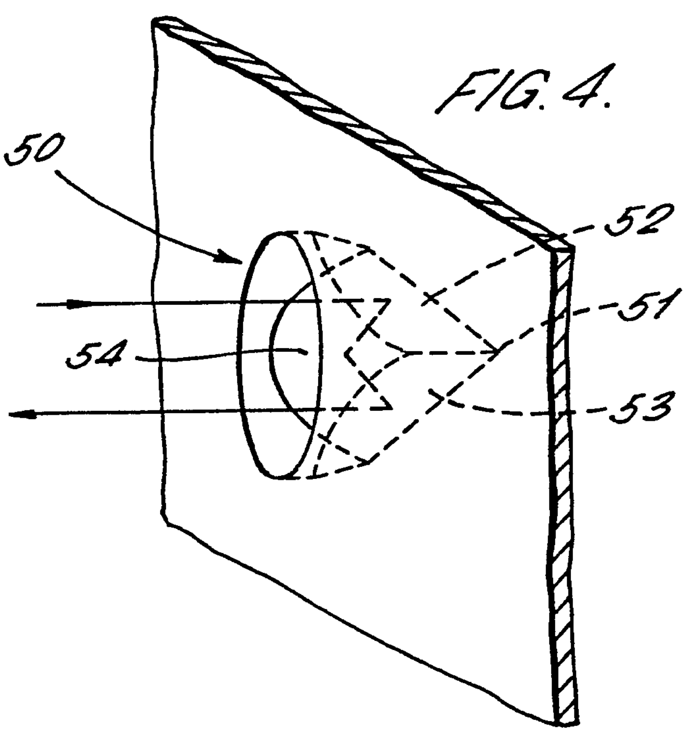
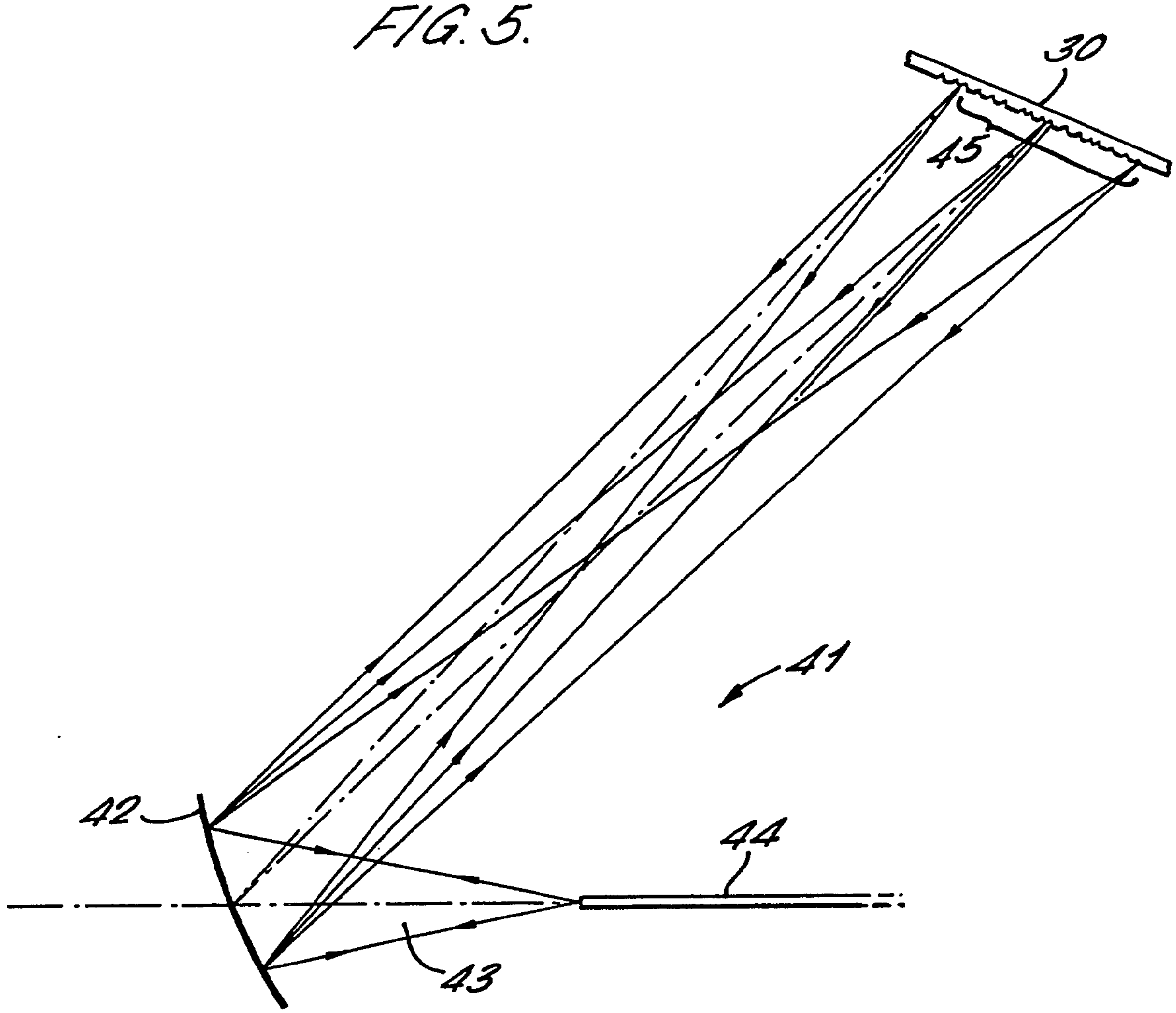


FIG. 4.

FIG. 5.



"OPTICAL APPARATUS"

This invention relates to optical apparatus comprising an optically detectable coded track and a sensor head enabling code from a selected portion of the track to be read, and in particular but not exclusively to optical apparatus for use in a displacement transducer in which the sensor head is used to read a code indicating the relative position of the head and the track.

It is known to provide a sensor head which directs light on to a selected portion of a coded track and for a reflector to be provided such that encoded light is reflected back into the sensor head to facilitate decoding. Typically the encoded light is transmitted from the sensor head to a remote decoding station for analysis.

Such reflector means may be provided by forming the track with a planar reflective surface carrying indicia which are non-reflective so that the spacial distribution of reflective and non-reflective portions embodies the code to be read. A disadvantage of such apparatus is that imperfect angular alignment of the track and sensor head due to vibration for example will reduce the amount of reflected light collected. Typically it is necessary to use an objective lens in proximity with the track in order to collect reflected light if significant light losses are to be avoided. The presence of such lenses may be unacceptable in certain hostile environments.

It is also known to provide optical apparatus having light dispersing means whereby different portions of the track are illuminated by light of different wavelength to facilitate wavelength division multiplexing of the encoded signal. It would be desirable in such apparatus to dispense with lenses

and utilise the dispersing means to disperse and direct light on to the track. In the absence of a light collecting lens however such an arrangement results typically in efficient collection only of light incident normally on the track and suffers substantial losses of light which is obliquely incident on the track.

According to the present invention there is provided optical apparatus comprising an optically detectable coded track, a sensor head operable to direct light on to a selected portion of the track to produce encoded light which is encoded with a signal representative of code embodied in the selected portion, and reflector means operable to reflect the encoded light so as to be received by the sensor head, wherein the reflector means comprises retroreflective means operable to reflect obliquely incident light through 180° such that encoded light is returned to the sensor head in a direction opposite to the direction at which it is incident upon the scale.

Preferably the light is encoded by transmission through the track and the retroreflective means comprises an array of retroreflective elements spaced from the track such that the track lies intermediate the array and the sensor head.

An advantage of such an arrangement is that light from the sensor head can be focused on to the track and light transmitted through the track will be incident upon the retroreflective means in an unfocused state. The size and position of the individual retroreflective elements need then not be specified to any specific tolerance and in particular the size of the elements need not be directly related to the spatial density of coding on the track.

Conveniently the array of retroreflective elements may comprise a portion of retroreflective

sheet material having transparent reflective beads distributed over a surface of the material.

Conveniently each of the beads may comprise a glass bead having a reflective coating applied to part of the bead's surface to provide retroreflection by internal reflection.

The track may be binary coded by means of a sequence of respectively opaque and transparent areas of the track. Conveniently the transparent areas of the track comprise holes.

Alternatively the track may be encoded by means of transparent areas of distinguishable transparency.

The optical apparatus may alternatively comprise retroreflecting means located on the track and comprising an array of retroreflective elements arranged such that the track is encoded in a manner determined by the spatial distribution of the elements.

Each element may comprise a groove formed in a surface of the track and defining mutually orthogonal reflective surfaces.

Alternatively the elements may comprise recesses formed in a surface of the track, each recess defining three mutually orthogonal reflective surfaces.

In each case such elements may be formed by indenting the track surface and applying a reflective coating to the reflective surfaces.

Alternatively the retroreflective elements may comprise strips of a retroreflective sheet material comprising an array of transparent beads arranged to provide retroreflection by internal reflection.

The sensor head may comprise light dispersing means whereby different portions of the track are illuminated by light of different wavelength to facilitate wavelength division multiplexing of the encoded signal.

The light dispersing means may comprise a

diffraction grating. Conveniently the grating is part spherical or cylindrical to provide focusing of the light on to the surface of the track. The need for an objective lens is thereby obviated.

The track may be encoded with a pseudo random binary sequence code. Such codes are described by way of example in GB-A-2126444.

The optical apparatus may constitute a displacement transducer in which the track is movable relative to the sensor head and the selected portion of the track identifies the position of the sensor head relative to the track.

Typically the sensor head will comprise a fibre optic link transmitting encoded light to a remote decoding station.

Particular embodiments of the present invention will now be described by way of example only and with reference to the accompanying drawings of which:-

Figure 1 is a schematic diagram of an optical apparatus in which light is encoded by transmission through a track;

Figure 2 is a schematic diagram of an alternative apparatus in which the track is scanned by a reciprocating mirror;

Figure 3 is a sectional view of a track having retroreflecting grooves;

Figure 4 is a perspective view of a retroreflective recess formed in a track surface; and

Figure 5 is a schematic view of a further alternative apparatus having a curved diffraction grating.

In Figure 1 an optical apparatus 1 comprises a sensor head 2 which is arranged to read code from a selected portion 3 of a coded track 4.

The track 4 is encoded with a PRBS (psuedo random binary sequence) code in which each binary 1 is

represented by a respective opaque portion of the track and each binary 0 is represented by a respective hole 5.

The sensor head 2 receives light from a remotely located source (not shown) via a fibre optic link 6, the light being formed into a collimated beam 7 by a lens 8, and the beam being incident on an inclined linear diffraction grating 9.

The diffraction grating 9 deflects the beam 7 through an objective lens 10 which focuses the light on to the track 4.

The selected portion 3 of the track 4 is thereby illuminated along its length by light of progressively varying wavelength due to the dispersing effect of the grating 9.

A sheet 11 of retroreflective material is located so as to extend parallel to the track 4 and spaced therefrom such that the track lies intermediate the sheet and the objective lens 10.

Light from the beam 7 which falls on to the selected portion 3 so as to be coincident with one of the holes 5 is able to pass through the track and is then incident upon the retroreflective sheet 11.

The retroreflective sheet 11 comprises a closely packed array of glass beads each being bonded to a backing sheet and having a metallised surface portion which faces the backing sheet. Internal reflection in the bead results in light being retroreflective so as to be returned after reflection through 180° along a line parallel to but laterally spaced from the line of incidence into the bead.

The maximum lateral displacement is approximately equal to the diameter of the beads so that beads of smaller diameter than the holes should preferably be used.

Light incident upon the retroreflective sheet

therefore is reflected back through the holes 5 to be collected by the objective lens 10. Such light is encoded with spectral information representative of the code present within the selected portion 3 since only those wavelengths will be present in the reflected light which correspond to positions in the selected portion 3 at which binary 0 is represented by a hole.

The encoded light collected through the objective lens 10 is returned through the sensor head into the fibre optic link 6 and is transmitted to a remote decoding station (not shown) at which the code present in the selected portion 3 can be read. The length of the selected portion 3 is selected such that there are sufficient bits of binary information to complete a word which uniquely identifies the location of the selected portion along the track 4.

Such an arrangement may be used as a linear displacement transducer in which the track 4 and the sensor head 2 are relatively movable and an output signal at the decoding station is indicative of the relative position.

The use of the retroreflective surface thereby enhances the efficiency of the sensor head and allows its operation with light of a lower intensity, thereby improving the available length of optical fibre which can be used in the fibre optic link and contributing to an overall improvement in noise level in the system.

An alternative optical apparatus 20 is shown in Figure 2 and will now be described using corresponding reference numerals to those of Figure 1 where appropriate for corresponding elements.

The alternative optical apparatus 20 has a sensor head 2 which directs light on to a selected portion 3 of a track 4 which is binary coded by means of holes 5.

A retroreflective sheet 11 extends parallel to and spaced from the track 4 such that the track 4 is intermediate the sensor head and the retroreflective sheet.

The sensor head 2 receives light from a light source 21 via a fibre optic link 6 from which emerges a divergent light beam 22 which is directed on to a concave mirror 23. The mirror 23 focuses the light on to the surface of the track 4 so as to illuminate a localised spot 24 which is small in size compared with the extent of a selected portion 3 of the track 4 which is to be read. The mirror 23 is reciprocatingly scanned such that the spot 24 rapidly moves backwards and forwards along the selected portion 3 to produce a serially encoded light signal constituted by light which passes through the hole 5 and is reflected from the retroreflective sheet 11.

Light reflected from the retroreflective sheet 11 returns through the hole 5 to be collected by the mirror 23 and refocused into the fibre optic link 6. Collected light is then transmitted to a detector 25 which is coupled to the link by means of a coupling device 26.

In Figure 3 an alternative arrangement is shown in which a track 30 formed from a metal plate 31 is encoded with a PRBS code by means of grooves 32 which constitute individually retroreflective elements. The grooves extend parallel to one another and are spaced at intervals defining the coding of the track 30 such that binary 1 is represented by the presence of a groove and binary 0 is represented by the absence of a groove.

Such a track 30 may be utilised in optical apparatus 40 of the type illustrated in Figure 5 in which a sensor head 41 comprises a plano-concave diffraction grating 42.

The grating 42 is arranged obliquely to a divergent light beam 43 emergent from a fibre optic link 44 so as to laterally deflect light on to the track 30. The track 30 is arranged such that incident light from the grating 42 is focused at points along the length of a selected portion 45 of the track. Light which is retroreflected from the grooves 32 formed in track 30 is encoded with code present within the selected portion 45 and is returned to the sensor head 41 where it is collected by the grating 42 and refocused into the fibre optic link 44 for transmission to a remote decoding station (not shown).

The optical apparatus 40 of Figure 5 may alternatively include a track 30 having reflective elements in the form of recesses 50 as illustrated in Figure 4. Each recess 50 comprises an indentation of circular profile formed in a surface of the track and having an apex 51 formed by the convergence of first, second and third mutually orthogonal plane surfaces 52, 53 and 54 respectively.

A linear array of such recesses 50 extends along the length of the track 30. Coding of the track is effected by the presence of a recess 50 representing binary 0 and the absence of a recess representing binary 1.

In an alternative arrangement the group of adjacent recesses 50 may together constitute a retroreflective element indicating binary 0.

The retroreflective elements described above with reference to Figures 3 and 4 may be formed by indenting or machining a surface of the track and subsequent application of a highly reflective surface coating to the mutually orthogonal surfaces.

CLAIMS:

1. Optical apparatus comprising an optically detectable coded track, a sensor head operable to direct light on to a selected portion of the track to produce encoded light which is encoded with a signal representative of code embodied in the selected portion, and reflector means operable to reflect the encoded light so as to be received by the sensor head, wherein the reflector means comprises retroreflective means operable to reflect obliquely incident light through 180° such that encoded light is returned to the sensor head in a direction opposite to the direction at which it is incident upon the scale.

2. Optical apparatus as claimed in claim 1 wherein the light is encoded by transmission through the track and wherein the retroreflective means comprises an array of retroreflective elements spaced from the track such that the track lies intermediate the array and the sensor head.

3. Optical apparatus as claimed in claim 2 wherein the array of retroreflective elements comprises a portion of retroreflective sheet material having transparent reflective beads distributed over a surface thereof.

4. Optical apparatus as claimed in claim 3 wherein the beads comprise glass beads each being provided with a reflective coating to provide retroreflection by internal reflection.

5. Optical apparatus as claimed in any preceding claim wherein the track is binary coded by means of a sequence of respectively opaque and

transparent areas of the track.

6. Optical apparatus as claimed in claim 5 wherein the transparent areas of the track comprise holes.

7. Optical apparatus as claimed in any of claims 1 to 4 wherein the track is encoded by means of transparent areas of distinguishable transparency.

8. Optical apparatus as claimed in claim 1 wherein the retroreflecting means is located on the track and comprises an array of retroreflective elements arranged such that the track is encoded in a manner determined by the spatial distribution of the elements.

9. Optical apparatus as claimed in claim 8 wherein each element comprises a groove formed in a surface of the track and defining mutually orthogonal reflective surfaces.

10. Optical apparatus as claimed in claim 8 wherein the elements comprise recesses formed in a surface of the track, each recess defining three mutually orthogonal reflective surfaces.

11. Optical apparatus as claimed in any of claims 9 and 10 wherein the elements are formed by indenting the track surface and applying a reflective coating to the reflective surfaces.

12. Optical apparatus as claimed in claim 8 wherein the elements comprise strips of a retroreflective sheet material comprising an array of transparent beads arranged to provide retroreflection

by internal reflection.

13. Optical apparatus as claimed in any preceding claim wherein the sensor head comprises light dispersing means whereby different portions of the track are illuminated by light of different wavelength to facilitate wavelength division multiplexing of the encoded signal.

14. Optical apparatus as claimed in claim 13 wherein the light dispersing means comprises a diffraction grating.

15. Optical apparatus as claimed in claim 14 wherein the grating is part spherical or cylindrical to provide focusing of the light on to the surface of the track.

16. Optical apparatus as claimed in any preceding claim wherein the track is encoded with a pseudo random binary sequence code.

17. Optical apparatus as claimed in any preceding claim wherein the track is movable relative to the sensor head such that the optical apparatus constitutes a displacement transducer.

18. Optical apparatus as claimed in any preceding claim wherein the sensor head comprises a fibre optic link for transmitting encoded light to a remote decoding station.

19. Optical apparatus substantially as hereinbefore described with reference to and as shown in any of the accompanying drawings.

Patents Act 1977
Exa..iner's report to the Comptroller under Section 17 (The Search Report) -12-

Application number

GB 9219938.9

Relevant Technical fields

(i) UK Cl (Edition K) H3H (HCD)

(ii) Int Cl (Edition 5) H03M

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI

Search Examiner

J DONALDSON

Date of Search

16 NOVEMBER 1992

Documents considered relevant following a search in respect of claims 1 TO 19

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1585561 (MARCONI) see whole document	1,8,13, 17

SF2(p) TP - doc99\fil000801

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).